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DOE /NASA CONTRACTOR REPORT

DOE /NASA CR-150806

SOLAR HEAT TRANSPORT FLUID (A Quarterly Report)

Prepared by

Houston Chemical Company
Post Office Box 4026
Corpus Christi, Texas 78408

Under Contract NAS8-32255 with

National Aeronautics and Space Administration
George C. Marshall Space Flight Center, Alabama 35812

For the U. S. Department of Energy

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U.S. Department of Energy

Solar Energy

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This work was done under the technical management of Mr. John Caudle, George C. Marshall Space Flight Center, Alabama.

16. ABSTRACT

This report covers the progress made in the development and delivery of noncorrosive fluid subsystems. These subsystems are to be compatible with closed-loop solar heating or combined heating and hot water systems. They are also to be compatible with both metallic and non-metallic plumbing systems. At least 100 gallons of each type of fluid recommended by the contractor will be delivered under the contract. The performance testing of a number of fluids is described.

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	UC-59c Unclassified-Unlimited William A. Brooksbank, Jr. WILLIAM A. BROOKSBANK, JR. Mgr, Solar Heating and Cooling Project Office

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INTRODUCTION

The purpose of this project is to demonstrate a solar heat transport fluid which will provide corrosion and freeze protection for aluminum, copper and steel solar collectors using copper plumbing.

SUMMARY

Evaluation and testing of the solar heat transport fluids are continuing. The evaluation of a steel solar collector plate by X-ray technique showed no indication of corrosion after 13 months of testing. It was determined and agreed upon by both NASA and PPG that the statistical data from flow and temperature data being generated was not beneficial. A quarterly review and inspection was held at the contractor's facility in Corpus Christi, Texas.

OPERATION OF THE SOLAR TEST STAND

Testing of the solar heat transport fluids is continuing on a 24-hour basis.

SOLAR HEAT TRANSPORT FLUIDS

Samples of the solar fluids are being taken monthly and analyzed for appearance, pH, and reserve alkalinity. The monthly and composite wet chemistry reports are enclosed.

COLLECTOR CORROSION EVALUATION

A contact was made with Chamberlain Mfg. Co. who have experience evaluating solar collectors for corrosion. Since the steel collector plates on test are a Chamberlain design, they have an interest in evaluating the collectors. It was agreed that Chamberlain will X-ray one of our NASA test collectors with the glazing in place and evaluate for corrosion.

System No. 7 with two parallel steel solar collectors using 50% ethylene glycol and deionized water with no inhibitor (M-0) was chosen. This system was chosen because it would be more likely to show evidence of corrosion than the other systems. The system contains no corrosion inhibitors and its pH is between 5 and 6. One of the two parallel collectors was removed from the test stand and the fittings, the insulation housing, and insulation were removed. The solar fluid was drained, purged with nitrogen and the inlet and outlet ports were plugged. This procedure was followed to eliminate the possibility of oxygen entering the collector plate fluid passages and causing corrosion.

The collector was shipped to Chamberlain's R&D Division in Waterloo, Iowa. A box was especially fabricated for the collector. Since we shipped the collector with its glazing in place, Chamberlain ran tests with another collector plate with and without the 1/8" Herculite glazing in place to study the effects of the single glazing. Chamberlain reported no loss in resolution of X-raying a plate with and without the 1/8" Herculite glass.

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The test collector was X-rayed and rings were noted around the welded areas. It was determined that the rings were residue ethylene glycol. The collector plate was then flushed with water and then alcohol and dried with nitrogen. There were no debris or rust from the above flushing. The collector was X-rayed and the rings around the welded areas disappeared. No corrosion was indicated by the X-rays after 13 months of testing.

The X-ray technique is being evaluated to determine if it will predict that corrosion is occurring. One of the approaches would be to determine by X-ray if corrosion is occurring rather than opening the collector plate and evaluating the corrosion.

SOLAR COLLECTOR PLATE PHYSICAL EVALUATION

The development of a procedure to open the internal passages for corrosion evaluation is proceeding. Rollbond aluminum solar collectors which were on stagnation test previous to this contract have been removed from their test stand. The collectors were disassembled and the collector plates internal passages were cut open by use of band saw. A film was noticed in the internal passage. This film was reported in an earlier report to be titanium dioxide which is used as a masking compound in the manufacture of the collector. No visual evidence of corrosion was apparent. Random samples were chosen and a cross section of the inner passage was prepared in cleaning solutions. These cross sections were mounted in plastic, polished, and examined under the microscope. Some interior crevice corrosion appears to have occurred in one of the cross sections examined.

QUARTERLY REVIEW

A quarterly review and inspection was held at the contractor's facility in Corpus Christi, Texas, on June 7, 1978. Those in attendance were:

John Caudle, NASA Technical Manager

Carl C. Clayton, PPG Sr. Project Engineer

John Wisnewski, PPG Program Manager

1. Reviewed the computer program which attempted to correlate the solar collector performance coefficients.

2. Discussed the procedure to evaluate the internal flow passages of the solar collectors at the end of the test period. We will continue to evaluate the aluminum solar collectors that were on stagnation test previous to this contract, which will help us develop the procedure. NASA plans to assist in developing a sampling plan which would allow us to minimize the number of flow passages to examine.

3. John Caudle inspected the solar test stand. He also inspected the disassembled collectors and their cut-open internal passages for corrosion.

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DATA ORGANIZATION

An attempt was made to take the daily solar collector temperature and flow data to compute statistical information by collector panel material and solar fluid. A computer program was written to organize this data to determine solar collector performance coefficients. The computer program calculated a heat flux ratio for each of the 64 solar collectors. The ratio was based on the ratio of the heat flux of the individual collector panel to the average heat flux for all the solar collector panels. It was determined and agreed upon by both NASA and PPG that the statistical data being generated was not beneficial. Therefore, no further attempts will be made to correlate this type of information.

TEST STAND ENGINEERING

PPG Engineering is supporting the solar project by monitoring test stand installation and by following up on engineering items such as drawing changes.

SOLAR PUMP TESTS

The Grundfos pump is still running and has completed 23 months of testing with no signs of failure on a continuous closed loop test.

SCHEDULE

A program schedule is attached and is layed out to show the actual work performed.

EXPENDITURES

There has been internal transfer on June 1, 1977 of this contract from Houston Chemical Company, Division of PPG Industries, Inc., to Development Department Corpus Christi Technical Center, PPG Industries, Inc. During the remainder of 1977 PPG Development absorbed its overhead charges. During the first quarter of 1978 the Accounting Department did not include the increase in rates in the NASA expenditure report. Further, it developed that time spent on this project during the first quarter was not charged on the NASA expenditure report. These differences are now included at the end of the expenditure report. NASA has not been invoiced for this difference.

NEXT REPORTING PERIOD

1. Sample all solar heat transport fluids every 30 days and evaluate them for deterioration and general performance by appearance, pH and reserve alkalinity analysis. Additional analysis for ash content, foaming, and viscosity will be made if a solar collector panel fails or at the end of the test period, whichever occurs first.

2. Develop procedures to determine when a solar collector panel fails and determine how to open collector panel internal passages for examination and determination of the corrosion rate.

3. Operate the solar test stand.

Sincerely,

John P. Wisnewski
Project Manager

bj

Enclosures

SOLAR HEAT TRANSPORT FLUIDS
NASA CONTRACT NAS8-32255

pH

System	Material	Fluid	Initial	7/15/77	8/15/77	9/15/77	10/15/77	11/15/77	12/15/77	1/15/78	2/15/78	3/15/78	4/15/78	5/15/78	6/15/78	7/15/78	8/15/78	9/15/78	10/15/78	11/15/
1	EPDM	M-5	9.9										9.7	9.7	9.6	9.7				
2	Cu	P-0	5.2	6.8	8.6	6.5	6.4	6.3	6.6	6.4	6.3	6.1	6.4	6.3	6.5	6.3				
3	Al	P-0	5.2	5.5	4.9	4.9	5.0	5.2	5.0	5.3	5.6	5.6	4.7	5.2	5.1	6.0				
4	Stl	P-0	5.2	5.9	5.1	4.9	5.1	5.1	5.0	5.3	5.8	5.7	4.9	5.2	6.2	6.2				
5	Cu	M-0	7.0	5.9	5.4	5.1	5.1	5.2	5.1	5.2	5.6	5.6	5.0	5.4	6.0	6.0				
6	Al	M-0	7.0	6.3	5.2	5.4	5.2	5.3	5.2	5.2	5.6	5.5	5.3	5.6	6.2	6.0				
7	Stl	M-0	7.0	4.8	4.8	4.9	5.3	5.2	5.0	5.2	5.6	5.4	4.9	5.4	6.2	6.2				
8	Cu	D-W	7.1	8.0	6.8	6.9	7.0	7.1	7.4	6.9	6.6	6.8	6.8	7.1	6.8	6.8				
9	Al	D-W	7.1	8.0	7.6	7.7	7.2	7.1		7.1	7.0	7.0	7.1	7.1	8.7	8.3				
10	Stl	D-W	7.1	5.6	6.3	6.1	5.9	5.9	5.9	6.1	5.9	5.7	6.4	6.3	5.8	5.8				
11	Cu	G-0	5.5	6.2	5.3	5.1	5.1	5.6	5.1	5.3	5.7	5.6	4.9	5.2	5.9	6.0				
12	Cu	T-1	9.6	9.5	9.8	9.9	10.0	10.1	10.0	10.1	10.1	10.2	10.1	10.1	10.2	10.3				
13	Cu	P-2	9.8	9.8	9.9	9.8	10.0	10.0	9.9	9.9	9.9	9.9	9.9	9.9	10.0	10.0				
14	Cu	P-1	9.8	9.6	9.6	9.5	9.6	9.6	9.6	9.5	9.5	9.5	9.6	9.6	9.6	9.6				
15	Cu	M-4	9.4	9.5	9.4	9.3	9.4	9.4	9.3	9.3	9.3	9.4	9.4	9.3	9.4	9.4				
16	Cu	M-3	9.5	9.4	9.4	9.3	9.4	9.4	9.3	9.3	9.3	9.4	9.4	9.4	9.4	9.5				
17	Cu	M-2	8.8	8.8	8.8	8.8	8.9	8.8	8.8	8.8	8.8	8.8	8.9	8.8	8.9	8.9				
18	Cu	M-1	9.4	9.3	9.2	9.2	9.3	9.2	9.2	9.2	9.2	9.2	9.3	9.2	9.3	9.4				
19	Cu	H-W	8.2	8.0	8.4	8.1	8.2	8.2	8.4	8.5	8.2	8.7	7.9	8.2	8.3	8.8				
20	Al	G-0	5.5	6.1	6.2	7.2	5.3	5.4	6.0	6.0	5.8	5.8	5.7	7.2	6.1	6.2				
21	Al	T-1	9.6	10.1	10.2	10.3	10.5	10.2	10.2	10.2	10.2	10.2	10.1	10.2	10.3	10.2				
22	Al	P-2	9.8	10.2	10.3	10.3	10.4	10.3	10.3	10.3	10.4	10.4	10.3	10.3	10.4	10.5				
23	Al	P-1	9.9	10.3	10.5	10.6	10.6	10.6	10.5	10.7	10.6	10.6	10.5	10.6	10.6	10.6				
24	Al	M-4	9.4	9.4	9.4	9.5	9.5	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.5				
25	Al	M-3	9.5	9.5	9.4	9.5	9.5	9.4	9.4	9.7	9.5	9.4	9.4	9.4	9.4	9.5				
26	Al	M-2	8.8	9.1	9.1	9.3	9.3	9.2	9.2	9.3	9.3	9.3	9.3	9.3	9.3	9.4				
27	Al	M-1	9.4	9.3	9.3	9.3	9.3	9.2	9.3	9.3	9.3	9.3	9.3	9.2	9.2	9.4				
28	Al	H-W	8.2	7.8	8.5	8.0	8.5	8.4	9.2	8.4	8.9	8.8	7.7	8.6	8.3	8.8				
29	Stl	G-0	5.5	5.9	5.2	6.6	6.5	5.3	5.2	5.7	5.5	5.5	5.2	5.0	5.5	5.4				
30	Stl	T-1	9.6	9.5	9.8	9.9	10.2	10.2	10.3	10.3	10.4	10.4	10.4	10.5	10.5	10.6				
31	Stl	P-2	9.8	9.8	9.8	9.9	9.9	9.9	9.9	10.0	10.1	10.0	10.0	10.0	10.1	10.2				
32	Stl	P-1	9.8	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6				
33	Stl	M-4	9.4	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.2	9.3	9.4				
34	Stl	M-3	9.5	9.2	9.3	9.2	9.2	9.2	9.2	9.2	9.2	9.3	9.3	9.2	9.2	9.3				
35	Stl	M-2	8.8	9.8	8.8	8.9	8.8	8.9	8.8	8.9	8.9	9.0	8.9	8.9	9.0	9.1				
36	Stl	M-1	9.4	9.3	9.2	9.2	9.2	9.3	9.2	9.2	9.2	9.3	9.1	9.2	9.2	9.3				
37	Stl	H-W	8.2	7.6	8.0	8.1	8.2	8.3	8.4	8.1	8.8	8.6	7.9	8.0	8.3	8.8				
38	Mix	T-2	8.7	-	8.9	8.5	8.7	8.6	8.8	8.6		8.7	8.7	8.6	8.6	8.7				

New fluid installed

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SOLAR HEAT TRANSPORT FLUIDS

NASA CONTRACT NAS8-32255

RESERVE ALKALINITY

Swatch	Material	Fluid	Initial	7/15/77	8/15/77	9/15/77	10/15/77	11/15/77	12/15/77	1/15/78	2/15/78	3/15/78	4/15/78	5/15/78	6/15/78	7/15/78	8/15/78	9/15/78	10/15/78	11/15/78
1	EPO	M-5	10.750										10.830	10.730	10.900	10.800				
2	Cu	P-0																		
3	Al	P-0																		
4	Stl	P-0																		
5	Cu	M-0																		
6	Al	M-0																		
7	Stl	M-0																		
8	Cu	D-W																		
9	Al	D-W																		
10	Stl	D-W																		
11	Cu	G-0																		
12	Cu	T-1	6.10	6.10	6.10	5.90	6.05	5.90	6.00	6.00	6.000	6.000	5.950	5.930	6.000	6.000				
13	Cu	P-2	6.25	6.30	6.20	6.10	6.15	6.10	6.20	6.10	6.100	6.100	6.080	6.080	6.080	6.200				
14	Cu	P-1	6.00	5.95	5.90	5.80	5.90	5.80	5.90	6.00	5.800	5.800	5.800	5.800	5.850	6.000				
15	Cu	M-4	6.65	6.50	6.50	6.50	6.50	6.40	6.50	6.50	6.500	6.500	6.430	6.430	6.450	6.500				
16	Cu	M-3	6.65	6.45	6.50	6.50	6.50	6.40	6.50	6.50	6.400	6.500	6.400	6.400	6.500	6.500				
17	Cu	M-2	11.45	11.30	11.40	11.30	11.35	11.20	11.40	11.30	11.300	11.300	11.330	11.380	11.350	11.400				
18	Cu	M-1	9.90	9.50	9.10	9.10	9.20	9.00	9.10	9.10	9.000	9.900	9.000	9.000	9.100	9.100				
19	Cu	H-W				0.120														
20	Al	G-0																		
21	Al	T-1	6.10	6.00	6.00	6.00	6.00	5.90	6.00	6.00	5.800	5.800	5.880	5.830	5.800	5.900				
	Al	P-2	6.25	6.20	6.25	6.20	6.23	6.20	6.40	6.30	6.200	6.200	6.130	10.100	6.150	6.300				
	Al	P-1	6.00	5.90	5.95	5.90	5.90	5.90	5.95	5.90	5.800	5.900	5.800	5.800	5.880	5.900				
	Al	M-4	6.55	6.60	6.65	6.60	6.70	6.55	6.70	6.60	6.600	6.600	6.530	6.550	6.600	6.700				
	Al	M-3	6.55	6.50	6.60	6.70	6.65	6.50	6.60	6.60	6.600	6.600	6.480	6.500	6.550	6.600				
	Al	M-2	11.45	11.50	11.50	11.40	11.50	11.30	11.40	11.50	11.400	11.400	11.350	11.350	11.450	11.600				
27	Al	M-1	9.90	9.90	10.00	9.95	9.90	9.80	9.90	9.90	9.800	9.800	9.780	9.750	9.900	9.900				
28	Al	H-W																		
29	Stl	G-0																		
30	Stl	T-1	6.10	6.10	6.05	6.10	6.05	5.90	6.10	6.00	6.000	6.000	5.950	5.930	6.000	6.000				
31	Stl	P-2	6.25	6.30	6.21	6.10	6.15	6.10	6.30	6.20	6.200	6.200	6.130	6.100	6.150	6.200				
32	Stl	P-1	6.00	5.90	5.90	6.10	5.90	6.00	6.00	5.90	5.900	5.900	5.830	5.850	5.850	5.900				
33	Stl	M-4	6.65	6.60	6.63	6.70	6.65	6.50	6.60	6.60	6.600	6.600	6.550	6.500	6.650	6.700				
34	Stl	M-3	6.65	6.60	6.58	6.60	6.60	6.50	6.60	6.60	6.600	6.600	6.530	6.480	6.550	6.600				
35	Stl	M-2	11.45	11.40	11.34	11.50	11.40	11.35	11.40	11.40	11.300	11.400	11.400	11.300	11.400	11.400				
36	Stl	M-1	9.90	9.90	9.840	9.80	9.85	9.70	9.90	9.90	9.800	9.800	9.700	9.700	9.750	9.800				
37	Stl	H-W																		
38	Mix	T-2	10.6	-	3.23	3.30	3.45	3.30	3.20	3.30		3.200	3.050	3.000	3.050	3.100				

NOTE: All blank spaces are <0.100

SOLAR HEAT TRANSPORT FLUID
VISUAL APPEARANCE TEST
NASA CONTRACT NO. 8-32255

System	Fluid	Material	7/15/77	8/15/77	9/15/77	10/15/77	11/15/77	12/15/77	1/15/78	2/15/78	3/15/78	4/15/78	5/15/78	6/15/78	7/15/78	8/15/78	9/15/78	10/15/78	11/
1	M-5	EPDM										100-250	100-250	100-250	100-250				
2	P-0	Cu	50-100	50-100	50-100	100-250	0- 50	0- 50	100-250	100-250	100-250	100-250	100-250	050-100	100-250				
3	P-0	Al	250-500	250-500	100-250	500 +	250-500	500 +	500 +	250-500	250-500	250-500	250-500	250-500	250-500				
4	P-0	Steel	250-500	250-500	250-500	250-500	250-500	250-500	250-500	100-250	100-250	500+	250-500	100-250	100-250				
5	M-0	Cu	100-250	100-250	100-250	100-250	100-250	100-250	100-250	100-250	100-250	250-500	100-250	100-250	100-250				
6	M-0	Al	250-500	100-250	250-500	250-500	500 +	500 +	500 +	500+	500+	500+	500+	500+	500+				
7	M-0	Steel	100-250	250-500	250-500	250-500	250-500	250-500	250-500	100-250	100-250	250-500	250-500	100-250	100-250				
8	[illegible]	Cu	50-100	100-250	50-100	0- 50	0- 50	0- 50	0-050	0-050	0-050	0-050	050-100	050-100	050-100				
9	[illegible]	Al	0- 50	50-100	0- 50	50-100	0- 50	-	50-100	100-250	100-250	050-100	000-050	000-050	000-050				
10	[illegible]	Steel	100-250	100-250	100-250	50-100	50-100	50-100	0-050	0-050	100-250	100-250	100-250	100-250	050-100				
11	C-0	Cu	100-250	100-250	100-250	100-250	100-250	100-250	100-250	100-250	050-100	250-500	100-250	100-250	100-250				
12	T-1	Cu	100-250	100-250	100-250	100-250	250-500	250-500	500 +	500+	250-500	500+	500+	500+	500+				
13	P-2	Cu	50-100	50-100	0- 50	0- 50	0- 50	0- 50	0-050	050-100	050-100	050-100	050-100	050-100	050-100				
14	P-1	Cu	100-250	50-100	0- 50	0- 50	0- 50	0- 50	0-050	0-050	050-100	050-100	050-100	000-050	000-050				
15	M-4	Cu	50-100	50-100	50-100	50-100	0- 50	0- 50	0-050	050-100	050-100	100-250	100-250	050-100	050-100				
16	M-3	Cu	50-100	50-100	50-100	0- 50	50-100	0- 50	0-050	050-100	050-100	050-100	100-250	050-100	050-100				
17	M-2	Cu	50-100	50-100	50-100	50-100	0- 50	0- 50	0-050	050-100	050-100	050-100	100-250	050-100	050-100				
18	M-1	Cu	50-100	50-100	50-100	50-100	0- 50	0- 50	0-050	050-100	050-100	050-100	050-100	050-100	050-100				
19	[illegible]	Cu	50-100	50-100	50-100	50-100	0- 50	0- 50	0-050	050-100	050-100	050-100	050-100	050-100	050-100				
20	C-0	Al	100-250	100-250	100-250	100-250	100-250	100-250	100-250	050-100	100-250	250-500	100-250	100-250	100-250				
21	T-1	Al	100-250	100-250	100-250	100-250	250-500	250-500	500 +	500+	500+	500+	500+	500+	500+				
22	P-2	Al	50-100	50-100	50-100	50-100	0- 50	0- 50	0-050	0-050	0-050	050-100	050-100	000-050	000-050				
23	P-1	Al	0-50	0- 50	50-100	0- 50	0- 50	0- 50	0-050	0-050	0-050	050-100	000-050	000-050	000-050				
24	M-4	Al	50-100	50-100	50-100	50-100	50-100	50-100	0-050	050-100	050-100	050-100	050-100	050-100	050-100				
25	M-3	Al	50-100	50-100	50-100	0- 50	50-100	0- 50	0-050	050-100	050-100	050-100	050-100	050-100	050-100				
26	M-2	Al	50-100	50-100	50-100	0- 50	0- 50	0- 50	0-050	050-100	050-100	050-100	050-100	050-100	050-100				
27	M-1	Al	50-100	50-100	50-100	0- 50	0- 50	0- 50	0-050	050-100	050-100	050-100	050-100	050-100	050-100				
28	[illegible]	Al	0- 50	50-100	0- 50	50-100	0- 50	0- 50	0-050	0-050	0-050	050-100	000-050	000-050	000-050				
29	C-0	Steel	100-250	100-250	100-250	100-250	100-250	100-250	100-250	050-100	100-250	250-500	100-250	100-250	100-250				
30	T-1	Steel	50-100	100-250	100-250	100-250	250-500	250-500	500 +	500+	500+	500+	500+	500+	500+				
31	P-2	Steel	50-100	50-100	50-100	50-100	50-100	50-100	50-100	100-250	100-250	100-250	050-100	050-100	050-100				
32	P-1	Steel	50-100	50-100	50-100	50-100	50-100	50-100	50-100	050-100	050-100	050-100	050-100	050-100	050-100				
33	M-4	Steel	50-100	50-100	50-100	100-250	50-100	50-100	50-100	100-250	100-250	100-250	100-250	100-250	100-250				
34	M-3	Steel	100-250	100-250	100-250	50-100	100-250	50-100	100-250	100-250	100-250	100-250	100-250	100-250	100-250				
35	M-2	Steel	100-250	100-250	100-250	100-250	250-500	100-250	100-250	100-250	100-250	100-250	100-250	100-250	100-250				
36	M-1	Steel	100-250	100-250	50-100	50-100	50-100	100-250	100-250	100-250	100-250	250-500	100-250	100-250	100-250				
37	[illegible]	Steel	50-100	0- 50	50-100	0- 50	0- 50	0- 50	0-050	050-100	100-250	0-050	000-050	000-050	000-050				
38	T-2	Mix	-	100-250	100-250	100-250	100-250	100-250	100-250		250-500	250-500	250-500	250-500	250-500				

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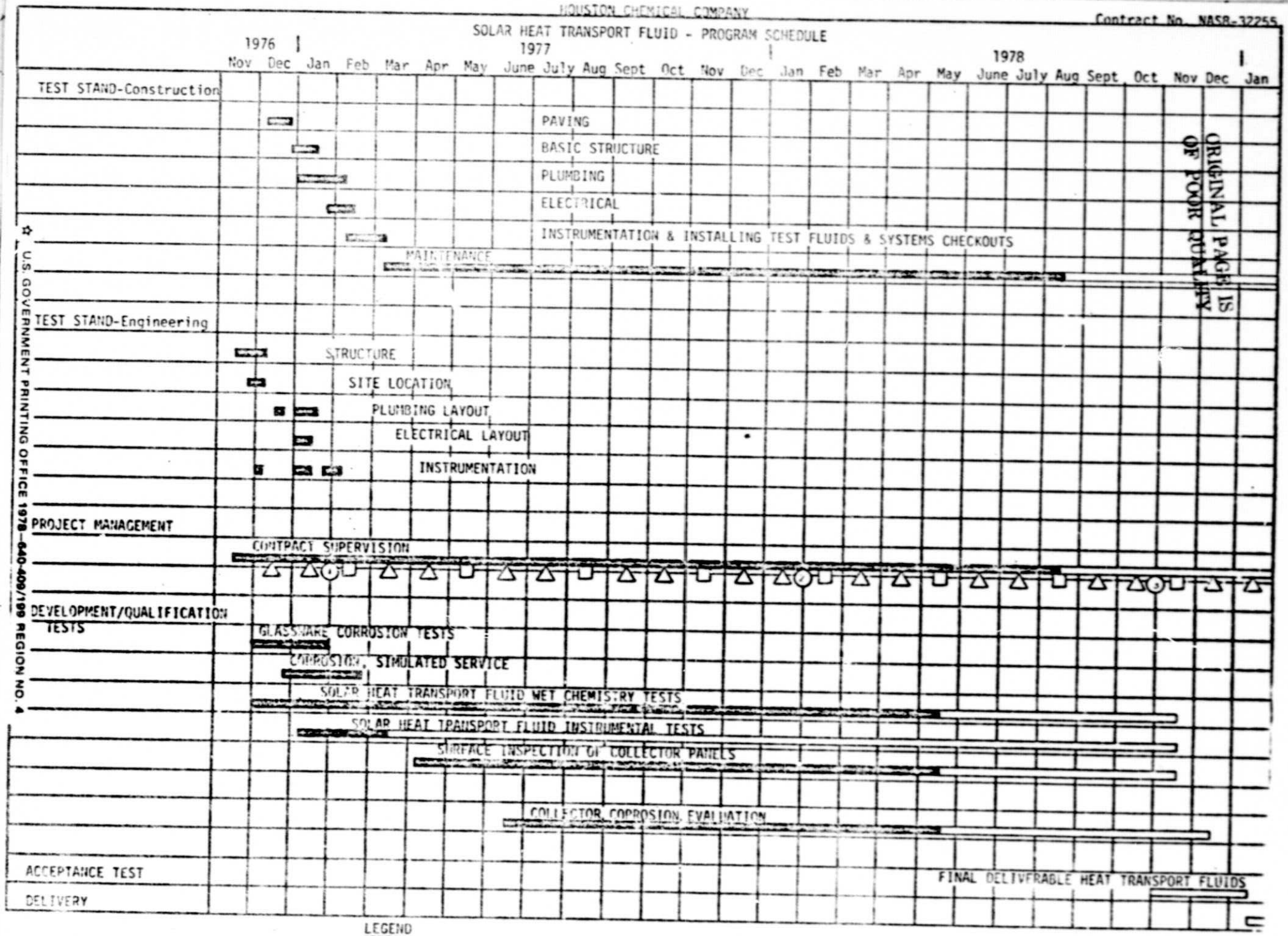
HOUSTON CHEMICAL COMPANY

Contract No. NASR-32255

SOLAR HEAT TRANSPORT FLUID - PROGRAM SCHEDULE



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LEGEND

- PROPOSED--BEFORE WEATHER DELAYS
- SCHEDULED
- COMPLETED
- △ MONTHLY STATUS REPORT
- □ - QUARTERLY REVIEW
- (1) PRELIMINARY DESIGN REVIEW
- (2) PROTOTYPE DESIGN REVIEW
- (3) FIRST ARTICLE REVIEW

Date 8/15/78

Submitted By